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VEGETATION MONITORING WITH PERMANENT PLOTS: A PROCEDURAL MANUAL FOR THE MID-ATLANTIC REGION

Technical Report NPS/MAR/NRTR - 90/046

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TABLE OF CONTENTS

INTRODUCTION

This manual was adapted by the author and Mid-Atlantic Region Science Program staff from a long-term vegetation monitoring program developed by the author for Hopewell Furnace National Historic Site. This work was sponsored by the Regional Science Program in an effort to provide guidance and standardization to parks in developing vegetation monitoring programs. Science program staff will continue to revise this manual to incorporate improved vegetation sampling procedures and protocols, where appropriate. Adherence to the general sampling design and procedures described in this manual, although recommended, is not required. Many of the general procedures and methods should be widely applicable. However, more specific measurements will vary, depending on park monitoring objectives.

RATIONALE FOR VEGETATION MONITORING

Natural plant communities change constantly. For a park to manage its natural resources effectively, managers need to know what natural changes are expected and the anticipated directions and rates of such changes. They also need to recognize changes which are human-influenced and may disrupt a park's natural environment. The establishment of permanently marked plots for long-term monitoring is the best way to provide the information by which change can be detected. Changes can then be easily monitored where natural, or possibly arrested when unnatural and potentially deleterious. Vegetation monitoring will also provide the baseline data against which new management strategies and actions can be evaluated, providing an "early-warning" system for more subtle, deleterious trends in plant community composition.

Over the years, the data from a permanent monitoring system become ever more valuable, as the length of time and the range of variation that have been recorded increase. For example, cyclical shifts which may not have been detected before, because the period of the cycle is too long, can be detected by looking at the data for a permanent plot system that has been in effect for more years than the period of the cycle. Occasional or sporadic replacement of some species may also be detected over the long term, while over the short term it may appear that the species are not replacing themselves.

In summary, a permanent monitoring system can provide information about trends over time as well as information that will help in managing the natural resources that are being monitored. The system described in this manual is flexible, to meet different needs and time constraints. Although system establishment can be time-consuming, on-going measurements can be quite flexible. Certain high priority measurements should be repeated at frequent intervals; additional measurements, while desirable, may require more time or training than is regularly available. The individual park can establish its priorities, and design a system that will fit its needs and constraints.

PROCEDURES

The procedure for setting up a permanent plot system starts with a determination of goals for the system with relation to the mission of the park. Using knowledge of the park's vegetation and physical attributes, the best distribution of plots with regard to these goals can be determined, and the types of information to be collected can be specified. This manual provides the information necessary to site the plots, set up the monitoring system, and manage the data. All steps, especially the enumeration of goals, should be recorded in writing and stored in several locations for future reference.

Determining goals

Goals should be determined through consideration of the existing natural vegetation and the park's objectives relating to natural resource management. Possible goals and management questions are presented below. This is clearly not an inclusive list, but rather indicates some descriptive questions that might be posed to provide information of value for managing natural resources.

1. Determine patterns and rates of growth of canopy species from seedling to sapling to canopy.
   a. Is there a cyclical nature to seedling establishment?
   b. Are seedlings selectively grazed?
   c. What proportion of seedlings survive to sapling size (>1 meter tall)?
   d. What proportion of saplings survive to reach the canopy?
   e. What are the causes of death of seedlings, saplings, mature trees?
   f. Is the composition of the canopy changing? If so, in what direction? Is there any evidence of the reasons for the changes?
   g. Do changes appear to be directional (successional)?

2. Determine patterns and rate of replacement for dead or dying trees.
   a. Are gaps produced by dead trees rapidly or slowly colonized by tree saplings?
   b. Are colonizers the same species as the trees in the existing forest, or are they others?
   c. Do non-native species provide a large proportion of the plants that colonize these openings, so that gaps provide these species with a foothold in the forest?
   d. If non-native species do colonize the gaps in large quantities, do they last, as the canopy fills in over them, or do they get shaded out? Do they prevent the growth of native species?

3. Study successional changes.
   a. Are there consistent, directional patterns of species replacement?
   b. Are there consistent patterns of changes in ecosystem parameters (for example, standing crop and diversity)?
   c. Does past land-use affect the patterns?
   d. Does date of initiation of succession affect the patterns?

4. Determine the role of catastrophic disturbance.
   a. What are species responses to such disturbances?
   b. Do responses differ for different disturbances?
   c. What are rates of recovery from catastrophic disturbances?

5. Experimental manipulations.
   a. Effects of grazing.
   b. Effects of fire.
   c. Effects of competition by non-native taxa.

6. Analyze interactions of canopy, understory, and/or herbaceous cover affecting food supply or cover for local native fauna as well as reproduction of tree species.

7. Determine the importance of physical parameters such as soil, slope and aspect on the patterns and rates of change of the vegetation.

A carefully designed, thorough monitoring system will provide data of interest for all of these goals, but focusing on one or a few goals will provide more evidence with less effort, aimed at the most important questions for a specific park.

Allocation of Permanently Marked Plots

Efficient allocation of permanent plots is dependent upon good information on the variability and composition of existing vegetation. Ideally, a map of the plant communities of the park along with a description of these communities or cover types is a necessary first step.

Numbers and General Locations

Natural vegetation includes variability on many scales so it is necessary to establish as many plots as feasible to provide a reliable estimate of the mean condition. Appropriate statistical analyses of the data will depend on the adequacy of sampling, with multiple samples in each cover type. With only one or two plots in each of two cover types, for example, apparent differences between the two types can be confounded by natural variation within each cover type, a result of inadequate sampling. Similarly, multiple sampling of a single plot over time provides data on temporal changes, but there is no way to know whether the change is idiosyncratic for that plot or represents more general trends for the entire cover type. For statistically valid results, which may be necessary for management decisions, adequate replication of the sampling and randomization of the samples is necessary.

As an example, a park may want to determine the rates of change in three forest cover types which may have a successional relationship to each other. The park may wish to test the hypothesis that over 50 years cover type A will change to resemble the current cover type B, while B will come to resemble the current cover type C. Cover type C will replace itself.

To test this rather simplistic model, we would require several plots in each cover type, on the most representative slope, aspect, elevation, rockiness, etc. as possible. In general, a minimum of 5 plots in each cover type is recommended, though more would increase the reliability of statistical analyses and the ability to generalize from findings. If environmental attributes such as slope or soil type are highly variable within individual cover types, additional plots stratified by these factors might be necessary. It is recommended that a plant ecologist and/or statistician be consulted to assist in determining the appropriate number and placement of plots to test the management objectives.

Size and Shape

The amount and pattern of variation in the vegetation and the type of vegetation determine the choice of plot size and shape. In sampling temperate woody vegetation, it is necessary to have a plot large enough to include at least 10 - 15 trees, so that there is at least a minimal representative sample of the trees. A plot of about 400 m^2 is usually sufficient in the northeastern deciduous forest to sample tree species, although 500 or 1000 m^2 is preferable and more easily converted to hectares. A plot size of 100 m^2 for shrubs and 25 m^2 for herbaceous vegetation are recommended. For more discussion on this topic and procedures for developing species-area curves see Mueller-Dombois and Ellenberg (1974).

A decision about shape is determined by a balance between minimizing the "edge" effect and maximizing variation within the plot. A long narrow plot parallel to the direction of variation (e.g., slope) will include maximum variation, but may have too much edge. The more edge, the more decisions have to be made about whether a plant is inside or outside the plot, leading to inaccuracies in the data. A good balance between these factors is a rectangular plot with a ratio of 1:4 between the sides, i.e., 10 m x 40 m, and the long axis along the direction of maximum environmental variation. If the slope is minimal and variation does not appear to be directional, a square plot is recommended.

Circular plots are frequently used in forestry surveys because they have a minimum edge to area ratio, can be marked with only one center stake, and allow basal area estimates of tree species to be made from the center post using a surveying prism. However, measurement of tree diameters is no easier than for square plots, and mapping trees and other features in circular plots is more difficult. Square plots with stakes at each corner are easier to permanently mark and relocate, particularly when there is a potential for the stakes to be moved or lost by natural or human forces.

Plots for measuring shrubs and herbaceous vegetation may be nested within the tree plots. While a smaller area is sampled for shrubs and herbs than for trees, the area is usually divided into several plots inside the larger tree plot in order to sample more of the variability of these vegetation components. An example of nested plots is given in the methods section of this manual.

It is usual forestry practice to "slope-correct" plot sizes to provide an accurate estimate of board-feet of timber in an area of high relief. Plots are enlarged to account for the disparity between area on the ground and the horizontal projection onto a map. However, it seems more appropriate for most studies of the kind suggested here to have plots of equal area on the ground (ie. not slope-corrected), as they will generally not be used for estimating tree stocking for an area.

Finally, it is advisable to have plots as uniform in size and shape as possible within and among each major category of vegetation (forest, shrubland, or field) to facilitate analysis and comparisons as these areas change through management activities or natural processes.

<u>Locating Plots</u>

Because permanent plots must be fairly easy to relocate in the future, it is best to place them fairly near clear landmarks, if this does not unduly bias the sampling. However, they must be far enough from disturbances caused by edges such as roads or field boundaries not to be influenced by these, and also far enough (100 m or so) from frequently used areas (e.g. trails) not to attract casual attention.

Choose approximate locations on vegetation and topographic maps. In the field, walk through the area to be sampled for an hour or more to familiarize yourself with the typical aspects of the vegetation. Two heads are better for this than one, and if possible one or both should have a good knowledge of the local vegetation. When you believe that you know what to look for and what to avoid, choose an appropriate general area for the plots. This is obviously a subjective decision that should be made with as much knowledge as possible of both the vegetation and the goals of the sampling system.

Actual locations of plots should be chosen objectively within this general area. One technique to do this is to run parallel lines through the area, spaced far enough apart so that plots laid out along them would not overlap. Plots can then be located either systematically or randomly along these lines, i.e., at regular intervals or at intervals determined by randomly drawn numbers. A second technique to locate the plots is to draw a rough scale map of the area and overlay a grid of lines on this map, with ten horizontal and ten vertical lines. Using random numbers tables, choose as many pairs of numbers as are necessary to identify coordinates of one corner of each plot. It is not necessary to locate the exact points in the field with elaborate equipment, but to eliminate bias, you should use some standard technique such as pacing the approximate distance and direction from a known point to the plot corner. With either of these methods it may be necessary when locating the plots on the ground to move them in a predetermined direction if they originally included unnaturally disturbed areas.

As each plot is established, assign and record plot numbers, locations, sampling dates, and the names of field personnel on a Plot Location Form. (See Appendix 1 for examples of all data forms). Topographic and vegetation maps with each plot's location accurately labelled along with their specific coordinates should be stapled to the form and multiple copies made and stored in several locations. The orientation of the plots should be recorded. If there are not topographical constraints it is recommended that plot sides be oriented along the four cardinal directions. Use magnetic north in all compass readings but note declination from true north for future reference.

Workers should exercise caution in establishing plots to minimize vegetation disturbance. Plots can be established in the fall to spring dormant season. Walk outside of the plot boundaries whenever possible.

A list of equipment necessary for marking plots and data collection can be found in Appendix 3. Stakes for permanently marking plots must be permanent and easy to relocate. A recommended material is 1/2 inch diameter or larger PVC conduit. This does not corrode as do metal stakes, so it will be more permanent, and not leach metals into the soil. It is also easy to cut in the field, inexpensive, lightweight, and easy to obtain. Stake tops can be capped with a 3 5/8" square electrical base plate coated with plastic. If vandalism is an anticipated problem, the pipe can be sunk 5-10 centimeters below the soil surface before it is capped and can then be relocated with a metal detector.

Permanent stakes should be sunk at least 50 cm and preferably 75-100 cm into the ground with approximately 15 cm above ground. This may require excavating a hole in rocky soils. Preferably the hole should then be filled with cement to hold the stake in place. The pipe should also be filled with cement, where possible. If vandalism is not likely, the pipe may be painted a bright color to make it easier to relocate.

Use temporary stakes to establish plot corners until all distances and angles are accurate. A simple method for ensuring right angles is to measure 6 m out from the first corner stake along one plot side, 8 m out along the other side and then reorient these sides so that there is exactly 10 m between these two points. Measure the appropriate distances along these established directions and repeat the process to establish the other corners.

At each corner choose the two nearest, medium-sized (20-40 cm dbh), apparently healthy trees outside the plot as witness trees. Each of these trees should be tagged with a heavy aluminum tag, on which should be written with an engraving pen the distance and direction to the corner stake, and an identifying witness tree number (see the Plot Location Form). Tags should be attached 1.5 m above the ground on the tree side closest to the corner stake. For each tree record the following information: species, dbh, distance (from center of tree) and compass bearing (from center of tree) to the corner.

Locate the nearest road, building, or other permanent landmark (trails, even constructed ones, are not recommended, as with time they may be moved due to erosion or other reasons). Choose a specific, unlikely-to-be-moved marker at this landmark and note the compass bearing to be followed from there to the plot or to an intermediate location marker. The initial bearing may not be directly to the plot if a trail or other easily followed path is more appropriate to get closer to the plot. As you proceed to the plot, select and mark distinctive large and healthy trees as line markers about every 10 meters. Record the descriptive information as indicated on the Plot Location Form for each line marker. Attach aluminum tags labelled with the appropriate number (eg. LM1, LM2, LM3) at 1.5 m above the ground on each line marker tree. If there are too few trees, mark rock outcrops with metal pins or paint.

SITE CHARACTERISTICS

Complete the Site Characteristics Form for each plot to describe features and natural/human disturbances which may influence the vegetation. Always indicate plot location and number, sampling date, and field personnel before entering data.

Measurements

For the remainder of this manual it will be assumed that sampling plots are square with 20 meters on a side. Some procedures and forms will need to be revised if other plot sizes and shapes are used. Consultation with a vegetation sampling specialist is recommended.

Trees are sampled within the entire plot (400 m^2), saplings and shrubs are sampled within 4 randomly selected 5 m x 5 m subplots, and tree seedlings and herbaceous plants are sampled within two 1 m x 1 m quadrats located within each of the four selected subplots.

Six-letter plant species codes should be used on all forms to reduce field time and to facilitate computer data entry. A listing of the common and scientific names of all tree and shrub species from Hopewell Furnace, including six-letter codes, are listed in Appendix 2. The codes consist of a three-letter abbreviation for the genus followed by a three-letter abbreviation for the species. Each three-letter generic code is unique, i.e., there are no two genera with the same three-letter codes, so that data can be sorted on the first three letters, or genus, as well as on species. Duplicates for the last three species letters may occur, however, necessitating some creativity in assigning three-letter species codes that are unique. All new species should be coded in this manner.

Following plot establishment it is best to complete vegetation measurements in the following order to avoid problems with trampled vegetation: herbaceous plants, tree seedlings, shrubs, tree saplings, and trees.

Herbaceous Plants

Herbaceous plants (herbs) are those that do not have woody stems, including grasses, sedges, and broadleaved non-woody plants (forbs). Herbaceous plants are sampled within four of the 5 m x 5 m subplots depicted in the Plot Grid Map (Appendix 1). Using a table of random numbers, select four of the 16 subplots identified on the Plot Map. Carefully locate the four corners of each of the subplots and place a flag at each corner. Herbaceous plant measurements are to be taken within a 1 m x 1 m quadrat in the southwest and northeast corners of each of the four subplots and recorded on the Herbaceous Data Form.

Timing may be especially important for these measurements. As opposed to the woody plants, many herbaceous plants in deciduous forests are spring ephemerals, i.e., they disappear after blooming in the spring, or they may not appear at all until later in the summer. If the site manager needs a very accurate record of herbaceous cover, it may be necessary to sample three times during the growing season: mid-spring, mid-summer, and late summer or early fall.

All species should be identified where possible. This will be the most difficult part of the work for those who are not locally proficient taxonomists. It may be acceptable to record grasses or sedges as a group. An effort should be made to recognize the most common 50 or so broad-leaved herbaceous plants.

A sample of each unknown should be collected outside the plot if the species is common. A collected plant should include root, stem, leaves and flowers wherever possible. The specimen should have a label attached (small labels with strings already attached are convenient) and a unique number, which is coded to the data form. It should then be put in a plastic bag to be taken back to the office. In the office the plant should be placed carefully in a plant press, with leaves and flowers spread as well as possible.

Guidelines specified in the National Park Service Museum Collection Handbook should be followed in labelling the specimen. It will be necessary to record the date of collection, who collected it and where, habitat conditions, your unique unknown code number, and any critical features that might be lost as the plant dries (e.g., color of the flowers). Blotters and driers should be replaced every day until the specimens are dry. Specimens can be identified by a local botanist or taken to a university or equivalent herbarium for assistance.

Herbaceous plants may be recorded as simply present or absent, but it is preferable to estimate the cover. In each quadrat, record an estimate of cover for each species present, using the index described on the Herbaceous Data Form and listed below:

Cover Index

1 0-4% cover
2 5-25% cover
3 26-50% cover
4 51-75% cover
5 76-95% cover
6 96-100% cover.

Estimate cover by imagining that the plants are all together in one corner of the quadrat and estimating what proportion of the space they would cover.

Tree Seedlings

A seedling is a plant of a tree species, less than 1 m in height. Use the same subplots and quadrats as for herbaceous plants. In each of these eight quadrats, count and record the number of seedlings of each species on the Seedling Data Form using the following age classes: 1 year - no annual bud scars encircling the stem, >1 year - seedlings with stems exhibiting bud scars. It is difficult to differentiate more than one year's growth because of browse or uneven growth, so only two categories of age are used. If the "seedling" is actually a vegetative sprout, indicate this in the notes section. Try to identify seedlings to species. If unsure, collect a seedling, outside the permanent plot, for later identification. For each species in each plot record a code for browse damage and for insect damage (see codes on data form).

Shrubs

Shrubs are woody plants that are not expected to reach the canopy. They include both multiple-stemmed species such as black haw (Viburnum prunifolium) and small trees such as ironwood (Carpinus caroliniana) or dogwood (Cornus spp.). Shrubs are sampled within the entire boundaries of the four 5 m x 5 m subplots identified above. Record data on the Shrub Data Form. List all shrub species with estimates of their canopy cover relative to each subplot, using the same index used for herbs (see above). This method provides an estimate of the percent importance of each species in terms of cover.

Tree Saplings

A sapling is a plant of a tree species which is >1 m tall and <5 cm dbh. Saplings, as with the shrubs, are sampled within the entire boundaries of the four 5 m x 5 m subplots identified above. Record the following information on the Sapling Data Form. In each subplot count and record the number of live saplings of each species. Using the codes provided on the bottom of the form, evaluate and record an appropriate index for browse and insect damage.

Trees

A tree is a woody plant ≥5 cm dbh. Instructions for tree measurements are included in the Plot Mapping section below as this work is most effectively completed simultaneously. Tree measurements are to be recorded on the Tree Data Form. If tree height is an important measurement in your forests, the data form should have columns added for recording the data necessary to compute an estimate of tree height. If it is not, record an estimate of the average height of the forest canopy.

Additional Species In Plot

Carefully search the plot to identify any additional species of saplings, shrubs, seedlings, and herbaceous plants which were not present in the sampled areas but are present within the plot boundaries. Note these additional species (presence, not numbers) on the Additional Species Form. This information is important to determine floristic diversity on a unit area basis.

Plot Map

The following features: live and dead trees, stumps, logs, rocks, and paths, are to be mapped for each plot on the Plot Grid Map. Orient the form so that northernmost side of each plot is at the top of the map. Lay tapes with highly visible markers at 5 meter intervals along two adjacent sides of the plot. These will help define the 5 m x 5 m subplots and will provide guidelines for locating trees and other features in the plot as you mark them on the map. The features to map are indicated by the legend at the bottom of the form, along with their respective symbols. Definitions are provided on the reverse side of the form.

Starting at the northwest corner, locate features one subplot at a time, in numerical order. Measure from the two sides with tapes as near perpendicular as possible to the center of each feature to locate it on the map. Draw the object on the map, copying as carefully as possible the size and shape of the object where it is in contact with the ground. It may be necessary to move a marked tape along from one row to the next to locate the objects accurately. Include the following on the map:

Live Trees: Map each live tree, defined as tree stems ≥5 cm in diameter at 137 cm (dbh) on the Plot Grid Map. Starting with subplot one, number each tree consecutively in order by subplot. If a trunk has branched before 137 cm, note that on the plot map, enclosing as many stems as are present at 137 cm within a larger outline of the trunk, and give each stem a different number. Aluminum tags should be used to label each tree with its six-letter species code and tree number. Attach tags to the north side of trees. Where problems of vandalism or esthetics make it inappropriate to tag the trees, be sure that they are precisely located on the maps. Record all measurements and assessments indicated on the Tree Data Form as you map the plot. Procedures and codes are on the back of the form.

Dead Trees: Any dead tree, ≥5 cm in diameter at 137 cm should also be mapped and numbered consecutively along with and as described for live trees. However, indicate that the tree is "Dead" by placing a letter "D" in front of the number. Be as precise as possible with species identification. If the species identification is uncertain, describe the general type, such as oak or even hardwood. If the wood is hard enough to attach the tag with a nail, do so; if not, attach the tag with a wire around the trunk at about 137 cm. As for live trees, include all appropriate measurements and assessments for dead trees on the Tree

Data Form. Again, be sure to include the letter "D" in front of the tree number.

Stumps: Also map any stumps, defined as dead trees ≥5 cm in diameter at the ground, and <137 cm tall. As for dead trees, these should also be identified as precisely as possible and their diameters at the base recorded on the Plot Grid Map.

Logs: Any dead logs >15 cm at the largest diameter and >1 m total length (i.e., including branches) should be indicated on the map, with species identification where possible.

Rocks and Rock Outcrops: Large rocks, >50 cm across at the widest place, bedrock outcrops, or areas of rocks which extend >1 m with no soil at the surface should be mapped. Identification of the rock type should also be made where possible, i.e., conglomerate, gneiss, etc.

Paths: Any deer paths or other animal paths should be drawn in, and described where it is obvious what kind of animal made the path.

REMEASUREMENTS

Interval

The remeasurement interval depends on the goals of the project. In an older, fairly stable forest, annual or even biennial measurements may indicate very little change unless there has been a major local disturbance. On the other hand, in a dynamic system, such as a young successional stand, or if herbaceous vegetation is important, changes on an annual or biennial basis may be significant. Frequent remeasurements, every year or two, will record more "stochastic" or chance variability, (i.e. noise in the system). This may be evened out by a longer sampling interval, often many years, but the chance still exists that the year that is used will turn out to be atypical. Regardless of the goals, more frequent sampling is best. One can always make the decision to ignore odd years, use running averages, or employ some other technique to emphasize significant changes and deemphasize noise, but missed years cannot be made up.

Realistically, annual or even biennial sampling is unlikely, and if the plots are maintained and remeasured at longer intervals, say 3-5 years, the data will still be significant after many years. A sampling interval of no more than 5 yrs is recommended.

What if the plot is not remeasured for even longer, for whatever reason? The data will still be worthwhile, on a comparative basis, showing change over however long it was since they were last measured. The more repeated measurements there are, the more valuable they all become.

Time of year

If possible, remeasurements should be made at about the same time of year as the original measurements, probably best in late May or June in the eastern deciduous forest. There are at least two reasons for this: 1) disturbances, e.g., browsing or insect infestation, will have proceeded to the same point, and 2) herbs will have developed to about the same extent so identifications should be comparable. Again, this is the ideal. Deviations do not seriously compromise the data.

What Measurements to Make

Ideally, all measurements from the original year should be repeated. Practically, the measurements can be ranked according to their importance to the goals of the project. A possible ranking is given below.

Must Do

Check all tags on landmark trees, witness trees and plot trees, and check all corner stakes. Conducting such a check each year or two will ensure your ability to efficiently and accurately reestablish your plots when actual monitoring work needs to be done. It need not take much time if the field worker goes well-prepared to replace all damaged or missing tags and stakes.

High Priority

A new plot map should be completed as directed in the Plot Map section above. Indicate new dead and/or downed trees, and where earlier mapped downed trees have rotted away. Changes in the rocks should also be noted, as well as changed paths. Causes of mortality of seedlings and saplings should be indicated where possible. Map and include any "new" trees maturing from the sapling class.

Other Measurements

Other remeasurements could be made depending on the goals of the project. For example, to analyze forest vegetation stability, remeasurement of saplings and woody seedlings should be made first, then shrubs and herbs.

DATA ANALYSIS

The data analysis will vary according to the goals of the sampling project. Some basic information will, however, be common to any sampling project. Data forms should be coded in a uniform way so that such data can be compared not only from year to year but also from park to park, or compared with other permanent monitoring systems in the region. The format used for the sample forms included in Appendix 1 were developed originally for Hopewell Furnace NHS and may serve as a guide. Examples of several dBASE III Plus databases for storing and analyzing monitoring data are also included in Appendix 4.

Summary Data - Trees

It is recommended that data be analyzed on a per plot basis and summarized by cover type. Computations on a per hectare basis are also possible but with small sample sizes could give an erroneous impression of the stocking for an entire community. The following measures should be computed:

1. Number of species - the total number of different species within a plot and cover type.

2. Number of trees by size class - a frequency distribution showing the numbers of trees by 5 cm size class.

3. Frequency - the percentage of sample plots in which a given species occurs. This parameter is a crude measure of the evenness of distribution of the species within a cover type.

$$\text{Frequency} = \frac{\text{Total \# plots in which species i occurs}}{\text{Total \# plots}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency of species i}}{\text{Sum of frequencies of all species}} \times 100$$

4. Density - The average number of individuals of a species per sample plot.

$$\text{Density} = \frac{\text{Total \# individuals of species i sampled per plot}}{\text{Total \# of plots}}$$

$$\text{Relative Density} = \frac{\text{Density for species i}}{\text{Sum of densities for all species}} \times 100$$

5. Basal Area and Dominance - For an individual tree, basal area is the cross sectional area of its trunk at 137 cm. Trees of largest diameter in a community are usually also greatest in height and biomass and tend to play a predominant role in the structure and function of an ecosystem. Basal area is therefore used as an index of dominance.

$$\text{Basal Area} = 3.14 \times (\text{dbh}/2)^2$$

$$\text{Dominance} = \frac{\text{Total basal area of species i}}{\text{Sum of the areas of plots sampled}} \times 100$$

$$\text{Rel. Dominance} = \frac{\text{Dominance of species i}}{\text{Sum of dominance values for all species}} \times 100$$

6. Importance Value - It is common practice to create an artificial measure indicating the overall importance of each species in the plant community. The calculation recommended here combines relative density and relative dominance (another popular calculation also combines relative frequency).

$$\text{Importance} = (\text{Relative Density} + \text{Relative Dominance}) / 2$$

This calculation will yield similar values for a species with a few large individuals or a species with many small individuals. Both species would be important in the community, in terms of total biomass or cover, but for different reasons. Importance values allow you to compare a species' importance in different plots or cover types.

To compare the total vegetation among plots or cover types, indices are used that condense the data from the individual species into one composite value to indicate the heterogeneity of the plant community. A commonly used index is the Shannon-Weaver Index (H) as calculated below:

$$\text{Shannon-Weaver Index (H)} = - \Sigma P_i \log P_i$$

where P_i = Importance probability for each species = Importance value for each species/total of Importance values

See Mueller-Dombois and Ellenberg (1974) for discussion of additional indices.

Some summary work should also be done for the standing dead trees. This might include the number of dead trees per plot, the average dbh of dead trees, and an examination of the species of dead trees.

Summary Data - Saplings and Seedlings

These values should be calculated for both saplings and seedlings on a per plot basis and then summarized by cover type. Refer to the identical measures described above under Trees for descriptions and calculations.

1. Number of species.

2. Frequency and Relative Frequency.

3. Density and Relative Density - calculate for each species and for all species combined. For density, sum the number of species in subplots (saplings) and

quadrats (seedlings). As only a portion of the plot was sampled, density will not be on a per plot basis. Relative density measures are independent of the areas sampled.

Comparisons among Trees, Saplings and Seedlings

The species composition of live trees, saplings and seedlings within a plot or a cover type, may be most easily done on a pairwise basis, comparing trees with saplings and saplings with seedlings. The simplest way is to compare the species similarity using an index such as Sorensen's Index (I_S):

$$I_S = \frac{2C}{A + B} \times 100$$

A = total number of sapling species
B = total number of seedling species
C = number of species in common

For a more comprehensive comparison, values derived with this index can be used to compare trees, saplings or seedlings in all plots with each other; that is, if there are 10 plots, one can construct a 10 x 10 matrix of comparisons for trees, saplings or seedlings. The procedures to do this are referred to as ordination or classification. Before using them it is important to understand the underlying principles and problems of interpretation. Two useful references on these analyses are Gauch (1982) and Pielou (1984).

The same index can be used, but with different years rather than different life forms, e.g., one can compare seedlings or saplings from year 1 to year 2 or any other comparisons that seem appropriate to the goals of the project.

Summary Data - Shrubs and Herbs

As above, it is recommended that these data be analyzed on a per plot basis and summarized by cover type. Refer to the identical measures described above under Summary Data: Trees for descriptions and calculations.

1. Number of species.

2. Frequency and Relative Frequency.

3. Average cover/species.

Shrub and herb data can be compared among plots on the basis of the average cover for each species in each plot, or presence/absence. The midpoints of vegetation cover categories should be used in these calculations. More complex analyses are also possible, depending on monitoring objectives. A plant ecologist should be consulted for more specific recommendations.

General Comments

The basic characteristics and importance values described above should be calculated by species for each plot. Major characteristics (at least density, dominance, and importance value) of plots used to sample each cover type can then be compared in a table such as the following:

Species	Measure	plot 1	plot 2	plot 3	plot 4
ACRRUB	Density				
	Dominance				
	Importance Value				
QUEPRI	Density				
	Dominance				
	Importance Value				

The data expressed in this tabular form can be compared, and averaged for each cover type or group of plant communities being monitored. The data can also be compared between sampling dates. Graphical representation of the data in these tables will also facilitate comparisons among plots and cover types. As can be seen from this discussion, data analysis can be complicated. Care must be taken to set clear goals at the outset of the project, so that the results can be related to these goals. In addition, because the value of interpretations of the data are often dependent on understanding the background of the analytical methods used, it may be advisable to seek the advice of qualified scientists to help set up the project and to have the data analyzed by contract to qualified scientists.

SELECTED REFERENCES

Avery, T. E. and H. E. Burkhart. 1983. Forest Measurement. McGraw-Hill Book Co., New York. 3rd edition.

Gauch, Hugh G. 1982. Multivariate Analysis in Community Ecology. Cambridge University Press, Cambridge.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York.

The Permanent Plotter. Published by the Institute of Ecosystem Studies, The New York Botanical Garden, Mary Flagler Cary Arboretum, Box AB, Millbrook, NY 12545.

Pielou, E. C. 1984. The Interpretation of Ecological Data. John Wiley and Sons, New York.

APPENDIX 1: DATA FORMS

PLOT LOCATION FORM

Plot # ______ Date __________ Personnel ____________________________________

Plot Sizes: Plot ______________ Sapling/Shrub Subplots _____________
Tree Seedling/Herbaceous Quadrats ______________

Plot Location and Size: ____

Landmark description: ____
____

Landmark location: ____
____
____

LINE MARKERS (Begin at Landmark and proceed to plot. If marker is not a tree, use the Species/dbh columns to describe the object)

Marker #	Species	dbh(cm)	From Last Point: Compass Bearing	From Last Point: Distance(m)	Comments
LM1					
LM2					
LM3					
LM4					
LM5					
LM6					

WITNESS TREES (Place tags on side closest to corner stake)

Corner/ tree #	Species	dbh(cm)	From Tree to Corner: Compass Bearing	From Tree to Corner: Distance(m)	Comments
SW 1					
SW 2					
SE 1					
SE 2					
NE 1					
NE 2					
NW 1					
NW 2					

SITE CHARACTERISTICS FORM

Plot # ______ Date _________ Personnel ____________________________________
Location ____
____

PHYSICAL ENVIRONMENT

Elevation _______ meters

Slope ______ degrees Aspect: N NE E SE S SW W NW

Position on slope: ___ (1=Ridgetop, 2=Midslope, 3=Foot, 4=Flat, 5=Local depression)

Describe any hydrological features that may affect the plot: ________________
____

Geological Substrate: ____

Soil Type: ___ (1=Clay, 2=Silt, 3=Sand, 4=Sandy loam, 5=Silty loam, 6=Clay loam)

Soil Texture: ___ (1=Fine, 2=Medium, 3=Coarse)

Soil Name: ______________________________ (According to SCS map)

Litter Depth: ____ cm (average depth from surface of litter layer to top of mineral soil horizon)

A-Horizon Depth: ___ cm (average depth from top of mineral soil horizon to distinctive color change)

% Canopy Cover (at plot corners): ___ NE, ___ NW, ___ SE, ___ SW
(1=0-25%, 2=26-50%, 3=51-75%, 4=76-100%)

SITE DISTURBANCES

Describe any known human activities and their estimated dates (eg. forest management and tree cutting, agricultural, pasture) that may have affected the site: ____
____
____

Describe any known natural disturbances and their estimated dates (eg. major storms and windthrows, fires, insect infestations) that may have affected the site: ____
____
____

HERBACEOUS DATA FORM

Plot # ______ Date _________ Personnel _________________________________

SUBPLOT & QUAD	SPECIES CODE	PERCENT COVER	NOTES	SUBPLOT & QUAD	SPECIES CODE	PERCENT COVER	NOTES

COVER INDEX

1 = 0-4% cover
2 = 5-25% cover
3 = 26-50% cover
4 = 51-75% cover
5 = 76-95% cover
6 = 96-100% cover

* Record both the subplot number (see Plot Grid Map) and the quadrat (NE or SW) in the first column (ie. 4NE).

SEEDLING DATA FORM

Plot # ______ Date _________ Personnel ________________________________

SUBPLOT & QUAD	SPECIES CODE	TOTAL # SEEDLINGS	# SEEDLINGS 1 yr	>1 yr	BROWSE DAMAGE	INSECT DAMAGE	NOTES

* Record both the subplot and the quadrat (NE or SW) in the first column.

For each species record total # of seedlings, # of seedlings 1 yr in age (no bud scars), # of seedlings >1 yr, and browse and insect damage (see codes below)

SAPLING DATA FORM

Plot # ______ Date _________ Personnel ________________________________

SUBPLOT #	SPECIES CODE	TOTAL # SAPLINGS	BROWSE DAMAGE	INSECT DAMAGE	NOTES

For each species record total # of saplings, and browse and insect damage (see codes below).

Browse Damage Index: 1 = No browse injury apparent, 2 = Some leaves partially browsed and/or toothmarks on stems, 3 = Most leaves and some stems browsed, 4 = Browsed to the ground

Insect Damage Index: 1 = No insect damage apparent, few herbivorous insects seen on plant, 2 = Holes in leaves or edges eaten, or many insects on leaves and/or stem, 3 = Leaves or stems badly damaged, enough to alter function, 4 = Total defoliation

SHRUB DATA FORM

Plot # ______ Date _________ Personnel ________________________________

SUBPLOT #	SPECIES CODE	PERCENT COVER	BROWSE DAMAGE	INSECT DAMAGE	NOTES

For each species record the percent cover (see codes below), and browse and insect damage (see codes below).

Cover Index:

1 0-4% cover
2 5-25% cover
3 26-50% cover
4 51-75% cover
5 76-95% cover
6 96-100% cover

Browse Damage Index: 1 = No browse injury apparent, 2 = Some leaves partially browsed and/or toothmarks on stems, 3 = Most leaves and some stems browsed, 4 = Browsed to the ground

Insect Damage Index: 1 = No insect damage apparent, few herbivorous insects seen on plant, 2 = Holes in leaves or edges eaten, or many insects on leaves and/or stem, 3 = Leaves or stems badly damaged, enough to alter function, 4 = Total defoliation

TREE DATA FORM

Plot # ______ Date _________ Personnel _________________________________

SUB PLOT	TREE #	SPECIES CODE	DBH	CA	TD	OG	BS	BC	BL	R	LS	AS	FS	LF	ID	FU	NOTES

Average height of forest canopy _______ meters

TREE DATA FORM DESCRIPTIONS

For each tagged live or dead tree, record its subplot number, tree number (place a "D" in front of the numbers for dead trees), six letter species code and the following assessments:

DBH - Diameter at breast height, 137 cm. Be sure that tape measure is tightly held against the trunk and is level all the way around. If there is a swelling at 137 cm, measure the diameter just below the swelling and make a note under "notes". Measure to the nearest 0.1 cm.

CA - Canopy: 1 = > 25% of crown exposed to sky
2 = < 25% of crown exposed to sky
3 = understory
4 = standing dead

TD - Top Dead: Y/N

OG - Open Grown: Y/N

BS - Bole Multi-Stemmed below 137 cm: Y/N

BC - Bole Curved: Y/N

BL - Bole Leaning > 10 degrees: Y/N

R - Rooting Medium: 1 = mineral soil
2 = organic soil
3 = rock

LS - Lightening scar: Y/N

AS - Animal Scar (e.g. deer rack rubbing): Y/N

FS - Fire Scar: Y/N

LF - Log Fall Scar: Y/N

ID - Insect Damage: Y/N

FU - Fungus Growing on Bark: Y/N

NOTES - Record any appropriate comments.

Average Height of Canopy: Use a clinometer or other device to estimate the average height of the forest canopy over the plot.

ADDITIONAL SPECIES FORM

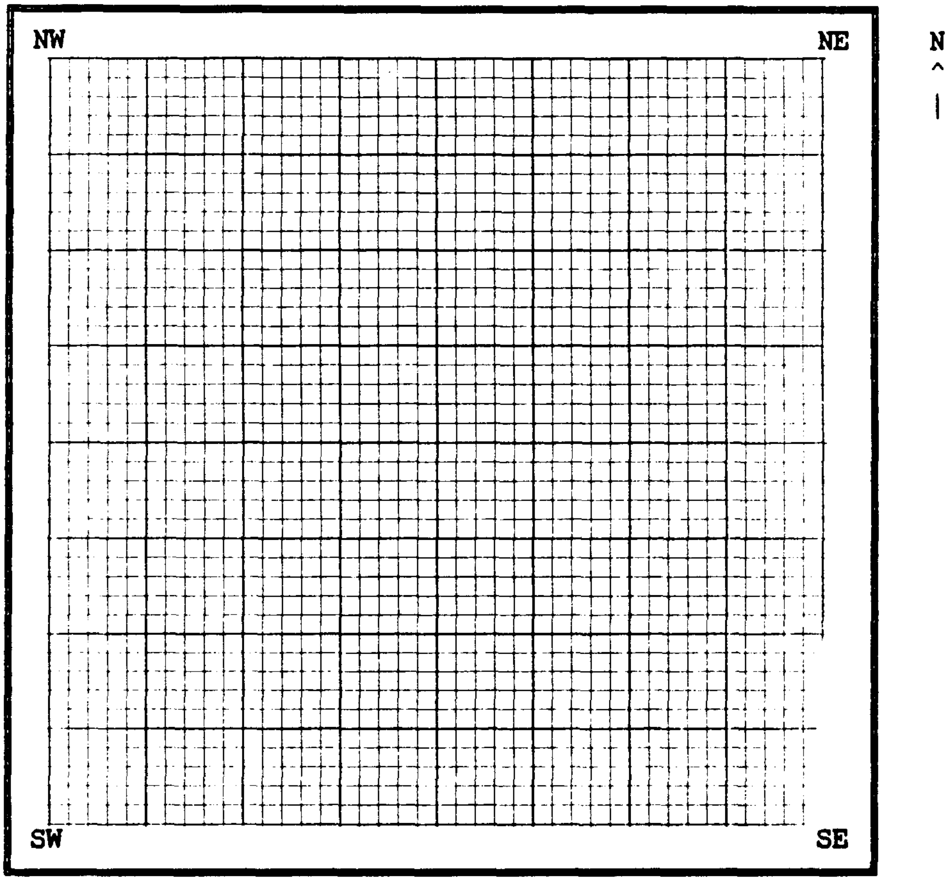
Plot # ______ Date _________ Personnel ________________________________

SPECIES	SAPLING	SHRUB	SEEDLING	HERB	NOTES

Search the plot thoroughly to identify and list any additional plant species which were not present in the sampled areas but are present within the plot boundaries. Indicate the type of plant (e.g. sapling, shrub) by placing a check in each appropriate box.

PLOT GRID MAP

Plot # ______ Date _________ Personnel ________________________________



Example: The recommended 20 x 20 meter plot is illustrated above; subplots are 5 meters on a side (10 blocks x 10 blocks), smallest blocks are 0.5 meters on a side.

Legend:

[#]	Live Tree	[D#]	Dead Tree
[X]	Stump	[///]	Log
[*]	Rock	---	Path

(See reverse for definitions)

Subplot layout:

1	2	3	4
8	7	6	5
9	10	11	12
16	15	14	13

* Number live and dead trees consecutively starting with subplot number one. Label the tree locations on the plot grid map with these numbers.

PLOT GRID MAP DESCRIPTIONS

Starting at the northwest corner, locate features one subplot at a time, in numerical order. Measure from two sides with tapes as near perpendicular as possible to the center of each feature to locate it on the map. Draw the object on the map, copying as carefully as possible the size and shape of the object where it is in contact with the ground. It may be necessary to move a marked tape along from one row to the next to locate the objects accurately.

Map the following items:

Live Trees: Any live tree stem ≥5 cm in diameter at 137 cm (dbh) (use a marked stick to locate 137 cm on the trunk). Starting with subplot one, number each tree consecutively in order by subplot. If a trunk has branched by 137 cm, note that on the plot map, enclosing as many stems as are present at 137 cm within a larger outline of the trunk, and give each stem a different number. Aluminum tags should be used to label trees with the six-letter species codes and tree number. Attach tags to the north side of trees. Where problems of vandalism or esthetics make it inappropriate to tag the trees, be sure that they are precisely located on the maps. Record all measurements and assessments indicated on the Tree Data Form as you map the plot. Procedures and codes are on the back of the form.

Dead Trees: Any dead standing tree, ≥5 cm in diameter at 137 cm should also be mapped and numbered consecutively along with and as described for live trees. However, indicate that the tree is "Dead" by placing a letter "D" in front of the number. Be as precise as possible with species identification, if species is uncertain describe the general type, for example, oak, or at least hardwood or conifer. If the wood is hard enough to attach the tag with a nail, do so; if not, attach the tag with a wire around the trunk at about 137 cm. As for live trees, include all appropriate measurements and assessments for dead trees on the Tree Data Form. Again, be sure to include the letter "D" in front of the tree number.

Stumps: Any dead tree, ≥5 cm in diameter at the ground, < 137 cm tall. As for dead trees, these should also be identified as precisely as possible and their diameters at the base recorded on the Plot Grid Map.

Logs: Any fallen dead logs > 15 cm at the largest diameter and > 1 m total length (i.e., including branches) should be indicated on the map, labelled with species identification where possible.

Rocks and Rock Outcrops: Large rocks, > 50 cm across at the widest place, bedrock outcrops, or areas of rocks which extend > 1 m with no soil at the surface should be mapped.

Paths: Any deer paths or other animal paths should be drawn in, and described where it is obvious what kind of animal made the path.

APPENDIX 2 - SPECIES CODES

TREES	CODES	COMMON NAMES
Acer negundo	ACRNEG	Boxelder
Acer rubrum	ACRRUB	Red Maple
Acer saccharinum	ACRSAN	Silver Maple
Acer saccharum	ACRSAC	Sugar Maple
Ailanthus altissima	AILALT	Tree-of-Heaven
Betula lenta	BETLEN	Sweet or Black Birch
Betula lutea	BETLUT	Yellow Birch
Broussonetia papyrifera	BROPAP	Paper-mulberry
Carya glabra	CARGLA	Pignut Hickory
Carya laciniosa	CARLAC	Big Shellbark Hickory
Carya ovata	CAROVA	Shagbark Hickory
Carya tomentosa	CARTOM	Mockernut Hickory
Castanea dentata	CASDEN	American Chestnut
Celtis occidentalis	CELOCC	Hackberry
Fagus grandifolia	FAGGRA	American Beech
Fraxinus americana	FRAAME	White Ash
Fraxinus nigra	FRANIG	Black Ash
Fraxinus pennsylvanica	FRAPEN	Green Ash
Juglans cinerea	JUGCIN	Butternut
Juglans nigra	JUGNIG	Black Walnut
Juniperus virginiana	JUNVIR	Red Cedar
Liriodendron tulipifera	LIRTUL	Tulip or Yellow Poplar
Morus alba	MORALB	White Mulberry
Nyssa sylvatica	NYSSYL	Black Gum
Pinus rigida	PINRIG	Pitch Pine
Pinus strobus	PINSTR	White Pine
Pinus virginiana	PINVIR	Virginia Pine
Platanus occidentalis	PLAOCC	Sycamore
Populus grandidentata	POPGRA	Big-toothed Aspen
Prunus avium	PRUAVI	Sweet Cherry
Prunus serotina	PRUSER	Black Cherry
Quercus alba	QUEALB	White Oak
Quercus bicolor	QUEBIC	Swamp White Oak
Quercus coccinea	QUECOC	Scarlet Oak
Quercus palustris	QUEPAL	Pin Oak
Quercus prinus	QUEPRI	Chestnut Oak
Quercus rubra	QUERUB	Red Oak
Quercus velutina	QUEVEL	Black Oak
Robinia pseudoacacia	ROBPSE	Black Locust
Salix nigra	SALNIG	Black Willow
Sassafras albidum	SASALB	Sassafras
Tilia americana	TILAME	Basswood
Tsuga canadensis	TSUCAN	Hemlock
Ulmus americana	ULMAME	American Elm

SHRUBS & SMALL TREES	CODES	COMMON NAMES
Alnus rugosa	ALNRUG	Speckled Alder
Alnus serrulata	ALNSER	Smooth Alder
Amelanchier canadense	AMECAN	Shadbush
Asimina triloba	ASITRI	Pawpaw
Berberis thunbergii	BERTHU	Barberry
Carpinus caroliniana	CRPCAR	Ironwood, Blue Beech
Celastrus orbiculatus	CLAORB	Oriental Bittersweet
Cephalanthus occidentalis	CEPOCC	Buttonbush
Cercis canadensis	CERCAN	Redbud
Clethra alnifolia	CLEALN	Sweet Pepperbush
Cornus amomum	CORAMO	
Cornus florida	CORFLO	Flowering Dogwood
Corylus americana	CRYAME	Hazelnut
Eleagnus umbellata	ELEUMB	
Euonymus americanus	EUOAME	Strawberry Bush
Gaylussacia baccata	GAYBAC	Huckleberry
Hamamelis virginiana	HAMVIR	Witchhazel
Ilex verticillata	ILEVER	Winterberry
Kalmia latifolia	KALLAT	Mountain Laurel
Ligustrum obtusifolium	LIGOBT	Privet
Lindera benzoin	LINBEN	Spicebush
Lonicera japonica	LONJAP	Japanese Honeysuckle
Lonicera morrowii	LONMOR	Tartarian Honeysuckle
Lyonia ligustrina	LYOLIG	Maleberry
Ostrya virginiana	OSTVIR	Hop Hornbeam
Parthenocissus quinquefolia	PARQUI	Virginia Creeper
Prunus virginiana	PRUVIR	Chokecherry
Rhododendron nudiflorum	RHONUD	Pinksterflower
Rhus copallina	RHUCOP	Winged Sumac
Rhus glabra	RHUGLA	Smooth Sumac
Rhus typhina	RHUTYP	Staghorn Sumac
Rosa multiflora	ROSMUL	Multiflora Rose
Rosa palustris	ROSPAL	Swamp Rose
Rubus allegheniensis	RUBALL	Blackberry
Rubus enslenii	RUBENS	Southern Dewberry
Rubus hispidus	RUBHIS	Dewberry
Rubus occidentalis	RUBOCC	Black Raspberry
Rubus phoenicolasius	RUBPHO	Wineberry
Sambucus canadensis	SAMCAN	Elderberry
Smilax glauca	SMIGLA	Catbriar
Smilax herbacea	SMIHER	Catbriar
Smilax rotundifolia	SMIROT	Catbriar
Smilax tamnoides	SMITAM	Catbriar
Symphoricarpos orbiculatus	SYMORB	Coralberry
Toxicodendron radicans	TOXRAD	Poison Ivy
Toxicodendron vernix	TOXVER	Poison Sumac
Vaccinium corymbosum	VACCOR	Highbush blueberry
Vaccinium stamineum	VACSTA	Deerberry

SHRUBS & SMALL TREES	CODES	COMMON NAMES
Vaccinium vacillans	VACVAC	Blueberry
Viburnum acerifolium	VIBACE	Maple-leaved Viburnum
Viburnum dentatum	VIBDEN	Arrowwood
Viburnum lentago	VIBLEN	Nannyberry
Viburnum prunifolium	VIBPRU	Blackhaw
Vitis aestivalis	VITAES	Summer Grape
Vitis labrusca	VITLAB	Fox Grape
Vitis riparia	VITRIP	River-bank Grape
Vitis vulpina	VITVUL	Forest Grape

APPENDIX 3: EQUIPMENT LIST

For marking plots:

PVC pipe, 1/2 or 1 inch
hacksaw for cutting PVC
large hammer and/or post hole digger
cement?
paint ("day-glo" or other bright color)
tree tags (Aluminum or plastic) and marking pens

For data collection:

tape measure
diameter tape or calipers
sighting compass
137 cm stick for dbh measurements
quadrat, 1 meter square
four 20 meter pieces of rope or line with marks at 5 m intervals
clipboard
data sheets
vegetation monitoring manual
random numbers table
plant ID books/keys
plastic bag and tags for plant unknowns and voucher specimens
flagging

APPENDIX 4: DATABASES FROM HOPEWELL FURNACE

Structure for database: C:vsite.dbf
Number of data records: 0
Date of last update : 08/07/90

Field	Field Name	Type	Width
1	PLOT_NUM	Character	2
2	DATE	Date	8
3	ELEV	Numeric	3
4	SLOPE	Numeric	2
5	ASPECT	Character	3
6	SLOPEPOS	Character	1
7	SOILTYPE	Character	1
8	SOILTEX	Character	1
9	SOILNAME	Character	15
10	LITTERDEP	Numeric	2
11	A_HORIZON	Numeric	2
12	CANOPY_NE	Character	1
13	CANOPY_NW	Character	1
14	CANOPY_SE	Character	1
15	CANOPY_SW	Character	1
16	NOTES	Memo	10
** Total **			55

Structure for database: b:vherb.dbf
Number of data records: 0
Date of last update : 08/07/90

Field	Field Name	Type	Width
1	PLOT_NUM	Character	2
2	DATE	Date	8
3	SUBQUAD	Character	2
4	QUAD	Character	2
5	SPECIES	Character	6
6	COVER	Numeric	3
7	NOTES	Memo	10
** Total **			34

Structure for database: C:vseed.dbf
Number of data records: 0
Date of last update : 08/07/90

Field	Field Name	Type	Width
1	PLOT_NUM	Character	2
2	DATE	Date	8
3	SUBPLOT	Character	2
4	QUAD	Character	2
5	SPECIES	Character	6
6	NUMBER	Numeric	3
7	AGE	Numeric	2
8	BROWSE	Character	1
9	INSECT	Character	1
10	NOTES	Memo	10
** Total **			38

Structure for database: C:vsapling.dbf
Number of data records: 0
Date of last update : 08/07/90

Field	Field Name	Type	Width
1	PLOT_NUM	Character	2
2	DATE	Date	8
3	SUBPLOT	Character	2
4	SPECIES	Character	6
5	NUMBER	Numeric	3
6	BROWSE	Character	1
7	INSECTS	Character	1
8	NOTES	Memo	10
** Total **			34

Structure for database: C:vshrub.dbf
Number of data records: 0
Date of last update : 08/07/90

Field	Field Name	Type	Width
1	PLOT_NUM	Character	2
2	DATE	Date	8
3	SUBPLOT	Character	2
4	SPECIES	Character	6
5	COVER	Numeric	3
6	NOTES	Memo	10
** Total **			32

Structure for database: C:vtree.dbf
Number of data records: 0
Date of last update : 08/07/90

Field	Field Name	Type	Width
1	PLOT_NUM	Character	2
2	DATE	Date	8
3	SUBPLOT	Character	2
4	TREE_NUM	Character	3
5	SPECIES	Character	6
6	DBH_CM	Numeric	5
7	CANOPY	Character	1
8	TOP_DEAD	Character	1
9	OPENGROWN	Character	1
10	BOLEMSTEM	Character	1
11	BOLECURVED	Character	1
12	BOLELEAN	Character	1
13	ROOTING	Character	1
14	LIGHTENING	Character	1
15	ANIMALSCAR	Character	1
16	FIRESCAR	Character	1
17	LOGFALL	Character	1
18	INSECT_DAM	Character	1
19	FUNGUS	Character	1
20	NOTES	Memo	10
** Total **			50

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-16 December 1990